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TO: Diane Harvester

FROM: Paul J. Pickett

SUBJECT: Investigation of Water Quality Problems in the Black River Between the Black River Canoe Club and the Mouth of Mima Creek

INTRODUCTION

The Black River has experienced serious water quality problems in the past, including the infamous Black River fish kill in August 1989 (WDOE, 1989). For this reason the river has been included in the Chehalis River Basin Total Maximum Daily Load (TMDL) study.

As part of the TMDL study, water quality monitoring was conducted from July to October 1991. That monitoring included field measurements and the collection of samples for analysis taken by boat on July 22, August 15, September 10, 11, 12, and 25, and October 9, 1991.

During the first survey on July 22, a Lowrance sonar device was used to observe the river bottom morphology. Several relatively deep pools were found, including one near the Black River Canoe Club launch (Canoe Club pool), and one just upstream of the mouth of Mima Creek (Mima Creek pool). Field measurements indicated depressed oxygen in the deeper areas of the river. In particular, the Mima Creek pool showed a deep layer of anoxic water, extending closer to the surface than any other area of the river monitored.

Following the first survey, I informed you of the conditions in the Mima Creek pool. You accompanied Elissa Ostergaard and myself during the second survey on August 15. During that survey we observed a foamy plume that appeared to be originating from a shallow drainage channel under the bushes at the bank just above the Mima Creek pool area. The water at the stream bank near this channel had a rotten, manure-like smell, bubbles rising up, and thick sediment at the bottom. No active flow was observed from the channel. Joe Joy and Bob Cusimano were working on the river that day and also observed the same conditions. Field measurements were taken from the river near the drainage channel. The drainage channel described here will be referred to below as the "suspect drainage".

As part of the rest of the surveys, some additional monitoring was conducted to evaluate water quality in the Black River from the drainage to the Mima Creek pool. This memo presents the data collected between the Canoe Club and Mima Creek and provides you with our recommendations.

STUDY AREA

The study area discussed in this memo is a subset of the larger study area for the Chehalis River TMDL. Since the water quality observed in the pool near Mima Creek and possible upstream sources were of principal interest, the study area extends from that area upstream. The Canoe Club pool was taken as the upper end since that is the next upstream pool with a database of equivalent size.

The Black River from the Canoe Club to Mima Creek is a slow wide quiescent water body. The shoreline is largely a dense natural growth of shrubs and trees with only isolated evidence of human activity. Flows are too slow to measure with conventional flow measurement equipment.

The Canoe Club is located at about river mile (RM) 14.1, based on the USGS topographic maps. The mouth of Mima Creek is located at RM 11.8. The suspect drainage channel discussed above is located at approximately RM 12.2. A map of the study area is provided in Figure 1.

Three pools were identified in this stretch of the river, the pool at the Canoe Club, a pool just above several old steel trestle posts at RM 13.1, and the pool above Mima Creek at RM 11.9. The Canoe Club pool is 4.9 meters (16 feet) deep, and the steel trestle pool and Mima Creek pools are 6.0 meters (20 feet) deep. Other areas of the river in the study area that have been monitored are approximately 4.0 to 4.7 meters (13 to 15 feet) at the deepest part of the channel.

METHODS

A summary of the monitoring data from the study area is provided in Appendix A.

Initially, stations were chosen for monitoring that were approximately one mile apart and coincided with the three pools discussed above. Sampling was conducted in July and August at these stations. Sampling at 2-meter depth increments in July was increased to 1-meter increments in August. In August, an additional set of field measurements was taken at the suspect drainage location.

For the intensive survey in early September, only the Canoe Club and Mima Creek pools were sampled. Samples were collected at 20% and 80% of total depth. During the third day, an additional station was sampled at 60% of total depth. That site was selected because it represented a more narrow and shallow location than the pools. Parameters collected and analyzed for during the three days of sampling included fecal coliforms, total organic carbon (TOC), turbidity, chloride, total persulfate nitrogen (reported here as "kjeldahl"), ammonia, nitrate/nitrite, and total phosphorus.

In late September and early October, stations were increased to a frequency of about one every half mile. This allowed stations to be placed in locations representative of a fuller range of typical channel configurations. In addition, monitoring was conducted in a grid around the suspect drainage. Stations were selected at both banks and midstream at the drainage location (RM 12.2), and about 0.1 mile above and below.

During the late September survey, fecal coliform samples were collected at several stations, and also from the suspect drainage ditch, from Mima Creek just above the mouth, and from the Black River just below Mima Creek. In October, TOC samples were collected from the grid stations near the suspect drainage.

Field observations of temperature, pH, dissolved oxygen (D.O.), and conductivity were made during all surveys with a Hydrolab Surveyor 2. D.O. and pH were pre- and post-calibrated daily and conductivity was approximately monthly with standard solutions per the manufacturer's instructions. D.O. was also measured from surface grabs using the modified Winker method in the EILS wet laboratory in Tumwater. No D.O. data was collected in the study area during the September 10 survey due to an equipment malfunction.

Samples were collected during the September surveys using a Van Dorm sampling device, except for fecal coliform samples which were taken as surface grabs directly with the bottle. TOC samples collected in October were taken as surface grabs with the bottle. All samples were immediately stored on ice, and were shipped by courier within 24 hours to the WDOE Environmental Laboratory in Manchester. Samples were analyzed using approved procedures (Huntamer and Hyre, 1991).

RESULTS

Dissolved Oxygen

The pool above Mima Creek is notable because of an anoxic layer that was observed from July through October. Anoxic is here defined as a D.O. measurement of less than 1.0 mg/L. The anoxic layer in this pool was found at depths as shallow as 3 meters in August, 4 meters in early September, 5 meters in late September, and near the bottom in July and October. Figures 2 and 3 show D.O. conditions in the Mima Creek pool both in terms of concentration and percent saturation.

Anoxic conditions were only found in two other locations during the entire sampling period. At a depth of 8 meters at RM 11.1, the deepest pool found on the Black River, anoxic conditions were found in August. Second, in August anoxic conditions were found at the right bank near the suspect drainage (RM 12.2) when that site was identified, and in late September at the deepest midstream river stations immediately downstream of the suspect drainage (RM 12.1 and 11.9). This situation will be discussed in more detail below.

In July, when D.O. was less than 3 mg/L at 4 meters and anoxic at 6 meters in the Mima Creek pool (RM 11.9), all D.O. measurements at other stations were over 5 mg/L. In August, when anoxic conditions near Mima Creek reached 3 meters depth, and in early September, when anoxic conditions were measured at 4 meters in the Mima Creek pool, no other station on the Black River had D.O. less than 4.9 mg/L. In late September and in early October, the lowest D.O. measured at any station in the Black River above the suspect drainage or below Mima Creek was 5.1 mg/L and was 4.8 mg/L, respectively.

Figures 4 and 5 show dissolved oxygen concentration and percent saturation in the study area at midstream stations during the September 25 survey. These plots demonstrate the pattern of D.O. described above. D.O. in the deeper layers at the Canoe Club (RM 14.1) and the Steel Trestle (RM 13.1) stations is depressed compared to the surface, but not anoxic. However, beginning at the site of the suspect drainage, anoxic conditions are found in midchannel near the bottom and can be observed downstream to the Mima Creek pool.

Conductivity

The pattern of conductivity in Black River in the study area follows closely the pattern of D.O. Conductivity in the shallower depths was found to be in the range of 90 to 100 μmho/cm. (All conductivity units reported here are as conductivity corrected to 25°C). In the deeper levels of the Canoe Club and Steel Trestle pools where oxygen showed a moderate depression, the conductivity was in the range of 120 to 150 μmho/cm.

However, as observed with oxygen, the area of the suspect drainage and the Mima Creek pool show distinctly different levels.

Conductivity in the Mima Creek pool was measured in the range of 500 to 800 μmho/cm during the August, September, and October surveys. Conductivity measured at midstream stations during the September 25 survey are shown in Figure 6. This figure demonstrates the disparity between the conductivity measured in the Mima Creek pool and measurements made elsewhere in the river.

Conductivity in shallow bank waters at the suspect drainage site ranged from 158 to 1600 μmho/cm, the highest observed in surface waters of the Black River during summer. Figure 7 shows the conductivity measured in the grid surrounding the suspect drainage during the latter surveys.

Laboratory Parameters

As described above, during the early September surveys, samples were collected at two depths in the Canoe Club and Mima Creek pools. Figures 8 and 9 show the results of analyses for turbidity, chloride, and nutrients, averaged over three days.

Figure 8 shows turbidity, chloride, and total phosphorus levels that are strikingly higher in the deeper level of the Mima Creek pool than in shallower depths or deep in the Canoe Club pool. Similarly, Figure 9 shows relatively large levels of ammonia and organic nitrogen in the deep station in the Mima Creek pool as compared to the other stations. The deep Canoe Club station shows the highest levels of nitrate/nitrite and larger total nitrogen than the shallow stations, but substantially less total nitrogen than deep in the Mima Creek pool.

Ammonia in the Mima Creek pool ranged from 28.3 to 31.1 mg/L during the three days of sampling. The temperature at this depth was close to 14°C and the pH was in the range of 6.7 to 6.8. The ammonia criteria for these conditions is 22.6 mg/L for acute toxicity and 1.8 mg/L for chronic toxicity (see Appendix B). The ammonia levels measured in the Mima Creek pool violate both acute and chronic toxicity criteria.

Figure 10 shows the results of sampling for TOC during the October survey from the grid stations near the suspect drainage. The TOC level of 10.5 mg/L is more than twice the next highest value of 3.7 mg/L. Values at bank stations other than the drainage ranged from 2.9 to 3.7, and in mid-stream the value was 1.2 mg/L.

Cluster Analysis of Data

The pattern of data described above indicates that different zones of the Black River have different water quality characteristics. To explore the water quality data patterns, the statistical software package SYSTAT® (SYSTAT, 1991) was employed to conduct a cluster analysis. Data was standardized and a K-means splitting method was employed. Two cluster analyses were conducted for this study; one of field data, and one of laboratory data from the early September surveys. The number of clusters chosen was the largest that resulted in groups that still exhibited logical temporal and spatial commonalities.

The laboratory data fall neatly into three clusters. Cluster 1 includes all samples collected from shallower depths in the Mima Creek and Canoe Club pools. Cluster 2 contains deeper samples from the Mima Creek pool and cluster 3 contains deeper samples from the Canoe Club pool.

Clustering of field data follows a similar pattern, but with some distinct differences. Cluster 1 contains deep stations upstream of the Mima Creek pool and surface stations in September and August. Cluster 2 contains the suspect drainage when first identified in August. Near-zero oxygen and conductivity of 1600 sets this case apart. Cluster 3 from the field data contains all deep stations in the Mima Creek pool. These data are characterized by very low oxygen and relatively high conductivity. Cluster 4 contains shallow depths for all stations in July and August.

Cluster analysis indicates how data tends to group itself based on a statistical test of similarity. The test does not evaluate the significance of the differences between groups. However, the analysis does support statistically what appears self-evident: the deepest areas of the Mima Creek pool are distinctly different and surface waters in general are distinctly different from deeper waters. A portioning of data into spatial zones for further analysis is reasonable and supported by the cluster analysis.

Statistical Significance of Spatial Variations

As a result of the analyses described above, SYSTAT was used to evaluate the spatial variation of the data. The data set for the study area was divided into four zones; two reaches, one upstream of the suspect drainage (> RM 12.3) and one from the drainage downstream (>= RM 12.2), and two layers, one less than 3.0 meters, and one three meters and deeper. Pairs of adjacent zones were compared for each parameter with a Kruskal-Wallis one-way analysis of variance.

A summary of the results of this analysis are summarized in Table 1. The lower the number in Table 1, the more significant is the difference between the data subsets. In addition, the zone with larger values is indicated. A number of parameters show significant differences between adjacent zones. Statistical significance is defined here as an alpha level of 0.05 or less.

In the shallow layer, data for conductivity, DO, chloride, turbidity, and ammonia show significant differences between upstream and downstream. Conductivity, oxygen, and chloride increase from upstream to downstream, but turbidity and ammonia decrease.

Table 1. Results of Kruskal-Wallis Analysis of Data: Probability that no difference exists. (Significance at alpha = 0.05 or less shown in **bold**)

	Upstream (U) vs Downstream (D)			
	Shallow Layer		Deep Layer	
	alpha	trend	alpha	trend
Conductivity	**<.001**	**U < D**	.061	
D.O.	**.006**	**U < D**	.028	
Chloride	**.032**	**U < D**	**.050**	**U < D**
Turbidity	**.028**	**U > D**	**.046**	**U < D**
NH_3-N	**.031**	**U > D**	**.050**	**U < D**
$NO_2/_3$-N	.077		**.050**	**U > D**
Total N	.121		.121	
Total P	.285		**.050**	**U < D**
Fecal Coli	.895			
TOC			.773	

In the deeper layers, D.O., chloride, turbidity, ammonia, nitrate/nitrite, and total phosphorus are significantly different. Downstream values are lower for oxygen and nitrate/nitrite, and higher for all other parameters. D.O., turbidity, and ammonia show trends in the deep layers that are opposite to the shallow layer. Although in the surface layers downstream oxygen is higher and turbidity and ammonia are lower, in the deep layers from the drainage point downstream the oxygen is significantly lower and the turbidity and ammonia higher.

CONCLUSIONS

After analysis of the data from the Black River from the Canoe Club to Mima Creek, several important conclusions can be made:

1. The water quality conditions in the Mima Creek pool appear to be unique to that site when compared to other areas of the Black River. No other station, including several pools of equal depth, showed oxygen depletion as severe as in the pool above Mima Creek. Other parameters, such as turbidity, chloride, total phosphorus, and ammonia nitrogen are all elevated in the deeper waters of the Mima Creek pool compared to a similar pool upstream. These differences are both evident from the graphs of the data, and can be shown with statistical significance.

2. The water quality conditions in the Mima Creek pool violate the Water Quality Standards (Chapter 173-201 WAC). Conditions of virtually no oxygen and ammonia as high as 30 mg/l are violations of criteria and create conditions of acute toxicity that are a severe threat to the beneficial uses of the river.

3. The water quality criteria violations observed in the Mima Creek pool are most likely caused by the discharge in the vicinity of the pool of pollutants that are oxygen-demanding, high in nutrients and high in solids. Since D.O., conductivity and other chemical parameters are unusually different in this area, an unusual source external to the normal natural processes in the Black River watershed appears to be the cause.

   The quality in the bottom of the Mima Creek pool is characterized by high levels of chloride and conductivity, high total phosphorus, and high ammonia and organic nitrogen. Since the effect is only observed at the bottom of the pool and is associated with high turbidity, a source that is high in solids is likely. These characteristics point to a high-nutrient solid or semi-solid waste.

4. Evidence points to a possible discharge of pollutants originating with the suspect drainage at RM 12.2. In addition to visual indications found in August, field readings showed extremely high conductivity and low oxygen at this location. TOC and conductivity were elevated at this location as compared to other bank locations. In addition, in late September a layer of water with low dissolved oxygen began at the drainage and ended at the Mima Creek pool. Similar patterns have not been found anywhere else on the Black River.

5. Although the suspect drainage appears to be a source location, the magnitude and specific cause of the source cannot be determined from the data discussed here. Also, the possibility that Mima Creek or some other unidentified sources contribute pollutants to the Mima Creek pool cannot be ruled out. However, a dairy farm north of the river is the most prominent

land use along the Black River in the study area, and is a possible source of wastes that could produce the effects documented in this memo, and therefore should be the first priority for follow-up investigation of possible sources of pollutants.

RECOMMENDATIONS

1. Whether a feasible pathway exists for pollutants to reach the Black River at the suspect drainage should be investigated. Evidence of a discharge of pollutants is circumstantial and must be connected with a specific source and discharge route. Methods could include site inspections and aerial surveys.

2. The possibility of other discharge locations, including Mima Creek, and the source of pollutants to those discharges should be investigated. This could include a survey of Mima Creek, possibly with sampling, county inspections of septic systems in the study area, and aerial surveys.

3. The Black River shows low levels of oxygen throughout the system that cannot be attributed to any one source, and the Waste Load Allocation/Load Allocation process will address that situation. However, all sources that contribute to water quality problems in the river must first be subject to adequate controls of pollutants. For point sources this would be accomplished with the use of "all known available and reasonable treatment" and the issuance of an NPDES permit. For nonpoint sources "best management practices" must be fully implemented.

   Any allocation of pollutant loading to the river must take into consideration these standards of pollutant control. If a specific source of pollutants to the Black River is discovered that appears to be contributing to the impacts described in this memo, efforts should be made to ensure that adequate measures are implemented to control that source.

REFERENCES

Huntamer, D. and J. Hyre. Manchester Environmental Laboratory, Laboratory Users Manual. July 1991.

SYSTAT, Inc. SYSTAT version 5.0. April 1991.

WDOE. The Black River Fish Kill Report. Washington Department of Ecology Publication No. 89-54. October 1989.

FIGURES

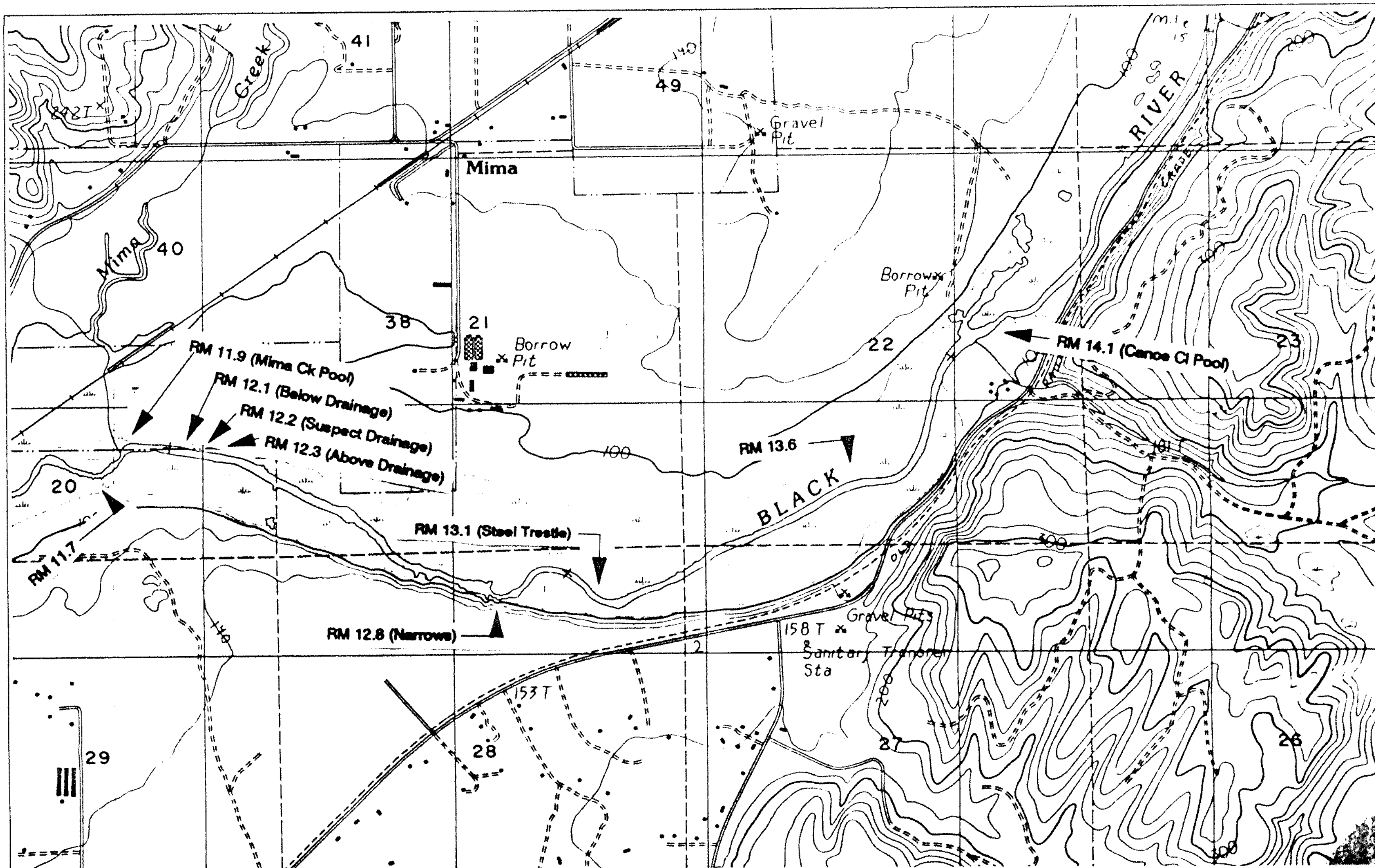


Figure 1. Map of Study Area
Black River, Canoe Club to Mima Creek

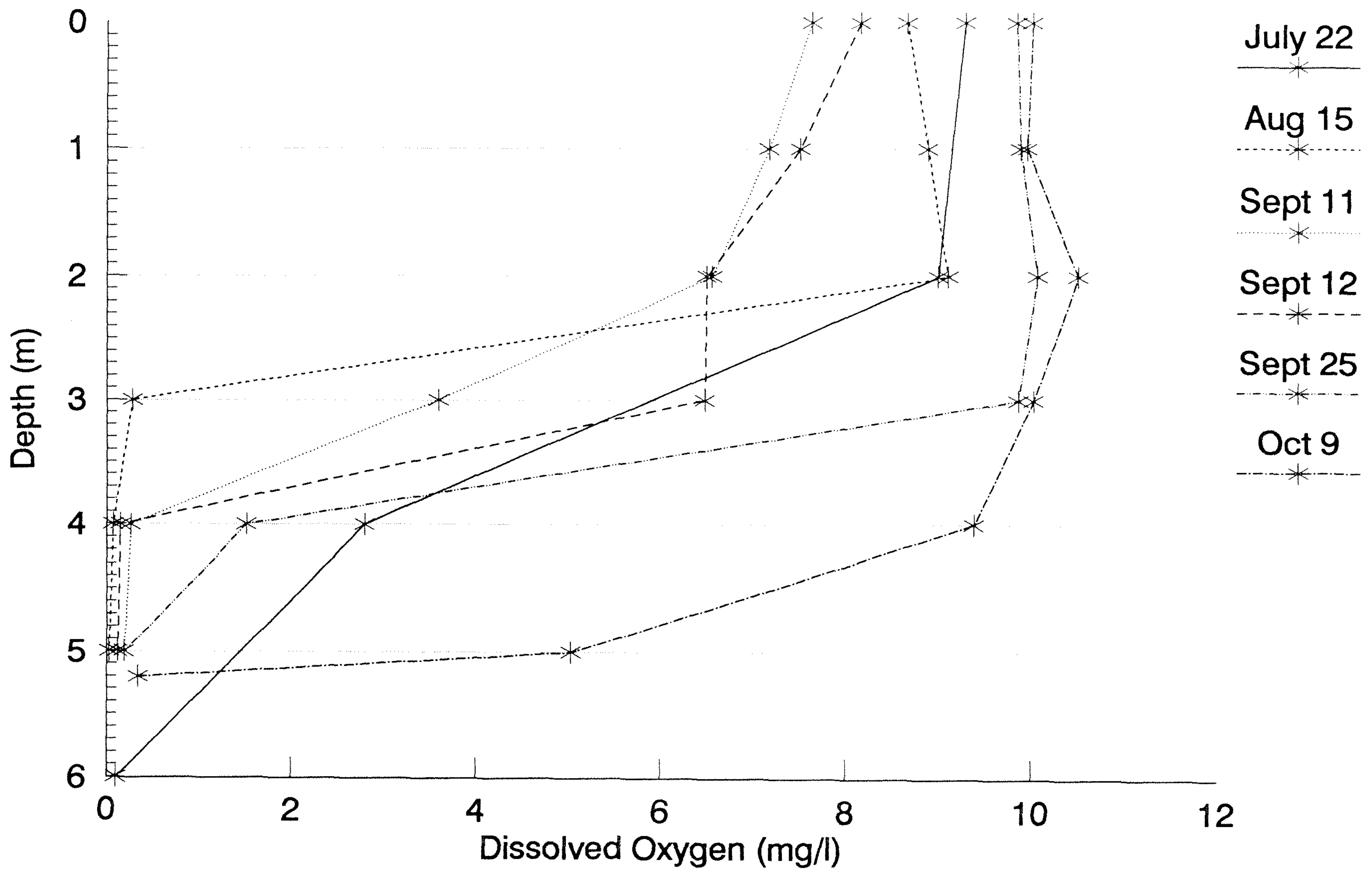


Figure 2. Dissolved Oxygen in Black River
Mima Creek Pool, RM 11.9

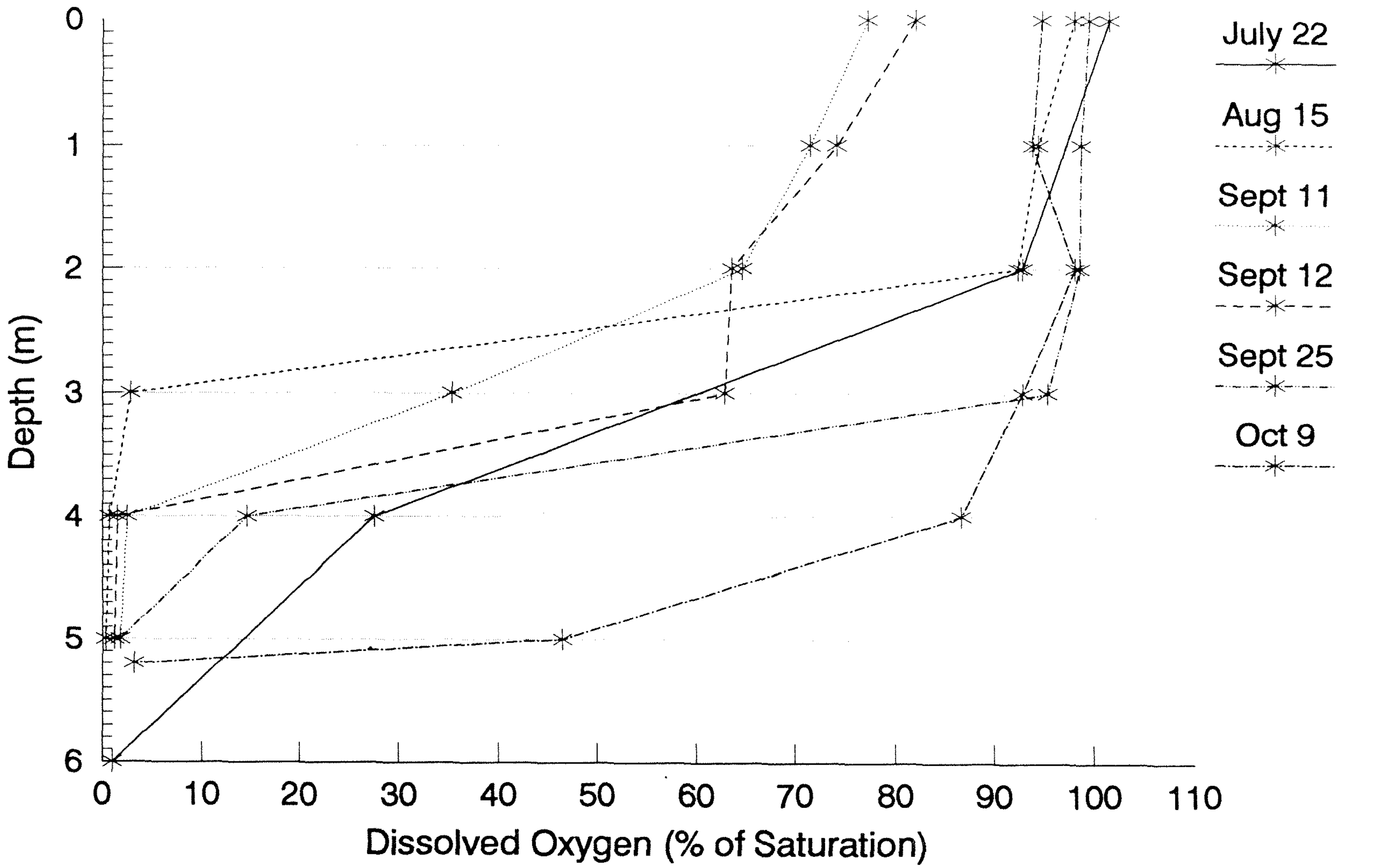


Figure 3. Dissolved Oxygen in Black River
Mima Creek Pool, RM 11.9

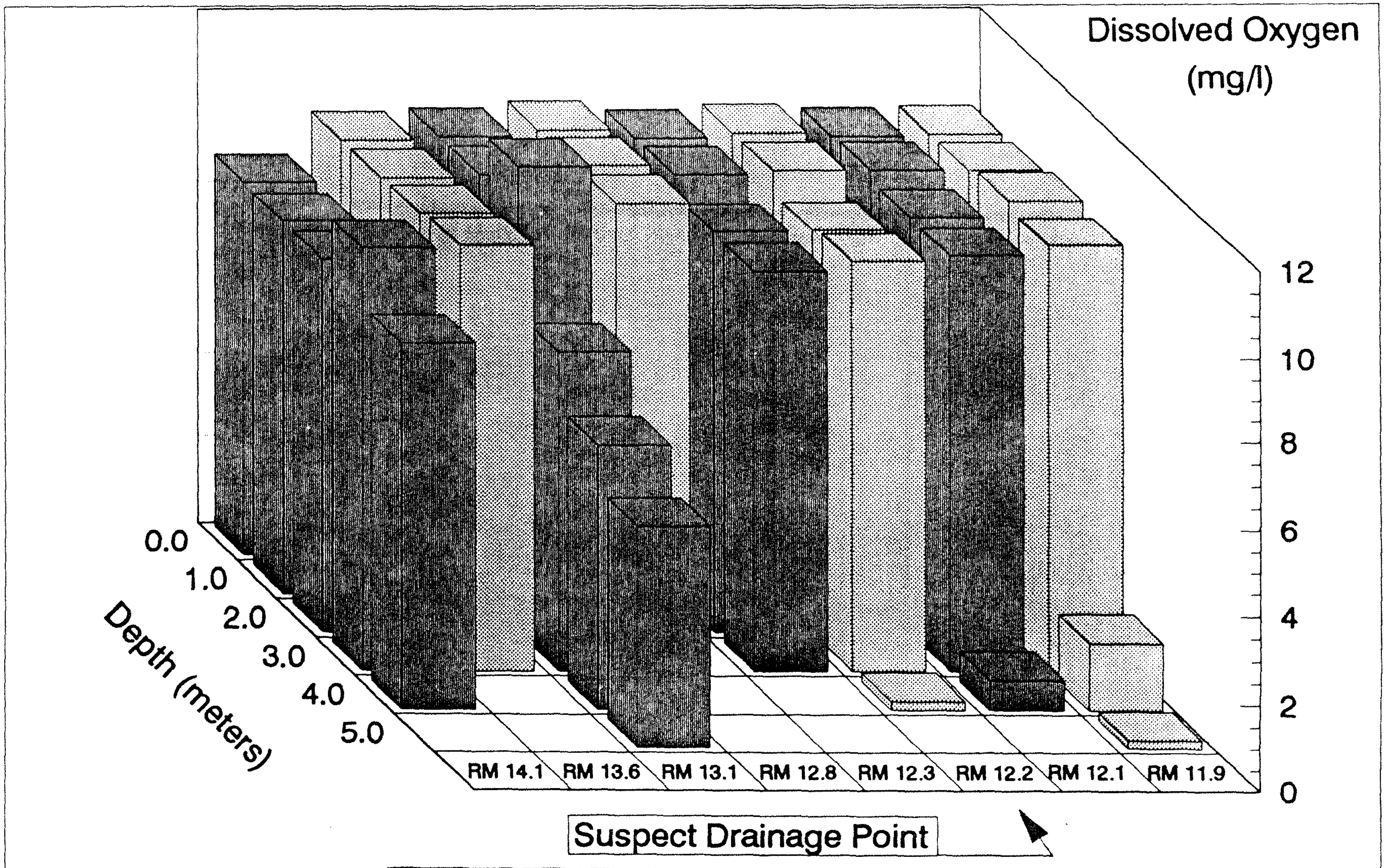


Figure 4. Dissolved Oxygen Concentration
Black River, September 25, 1991

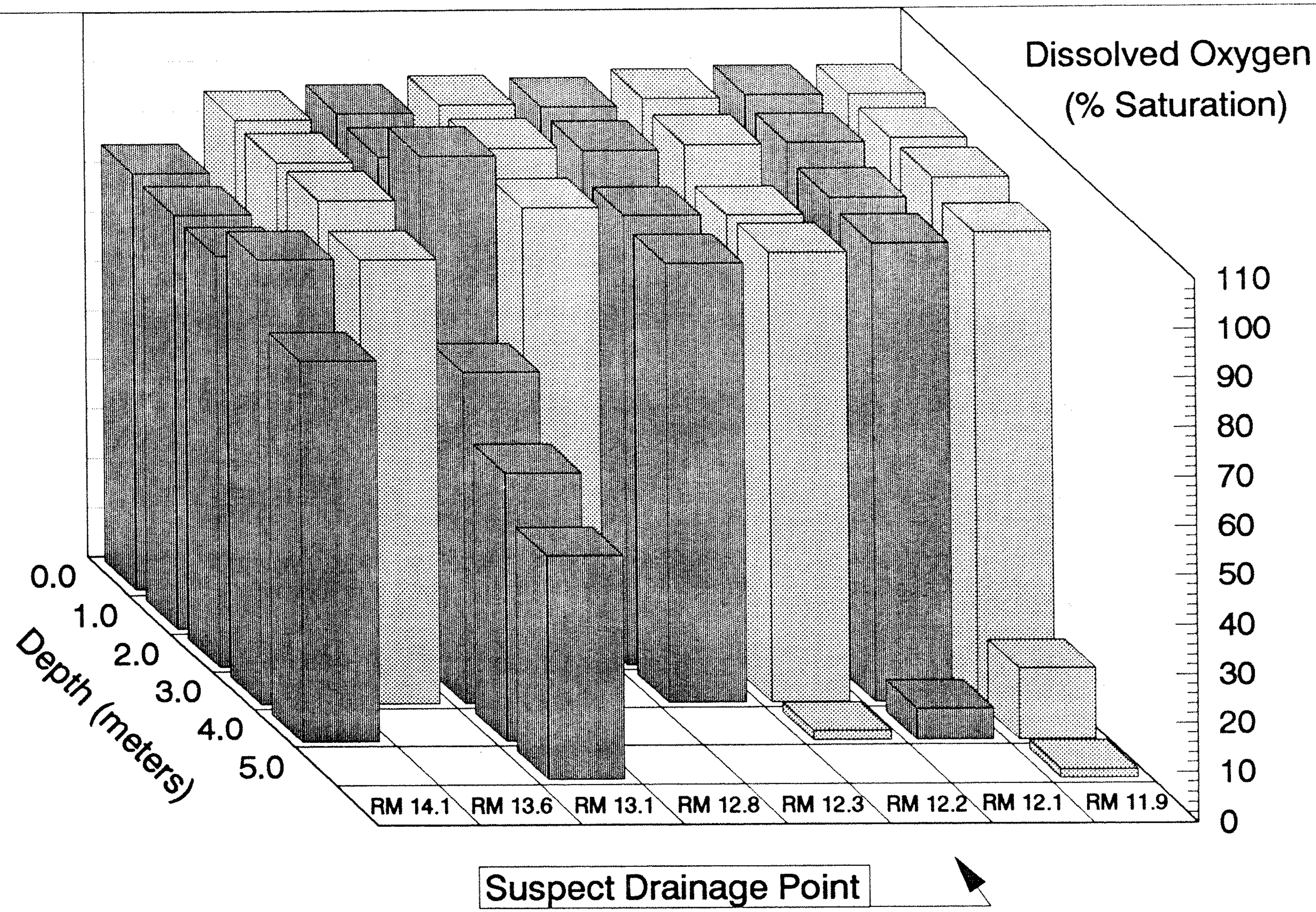


Figure 5. Dissolved Oxygen Percent Saturation
Black River, September 25, 1991

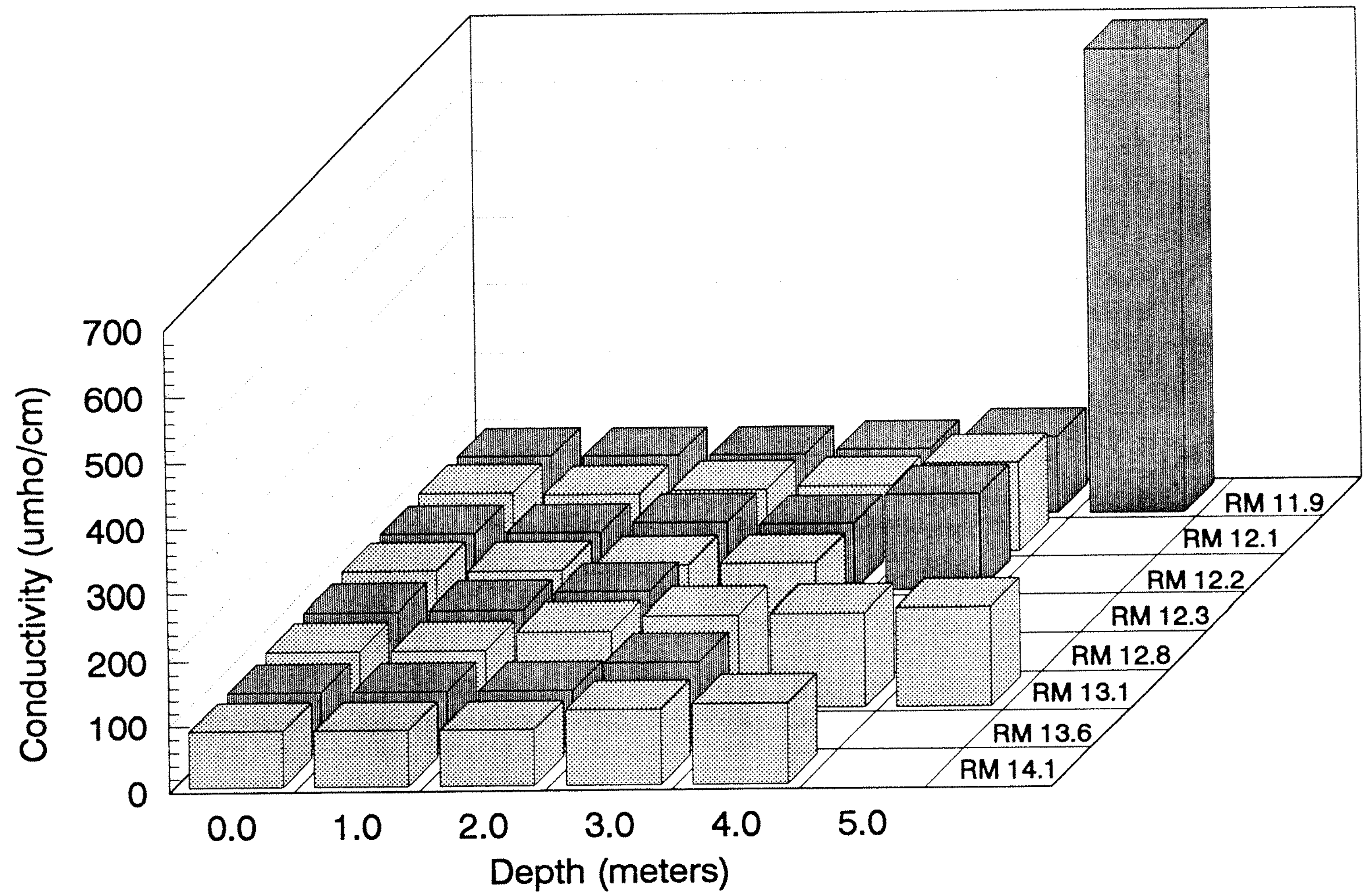


Figure 6. Conductivity in the Black River
September 25, 1991

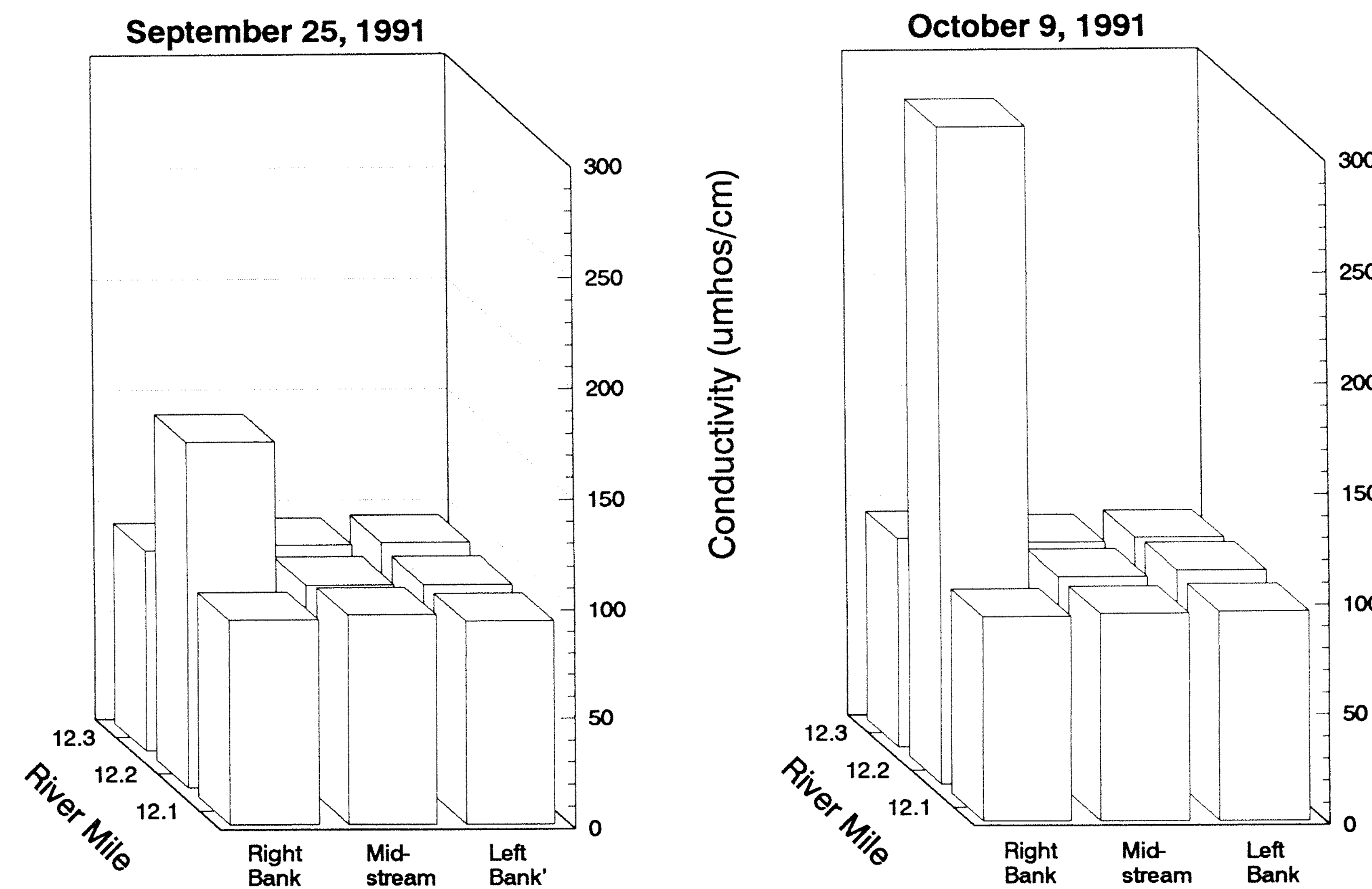


Figure 7. Conductivity in the Black River Vicinity of Drainage above Mima Creek

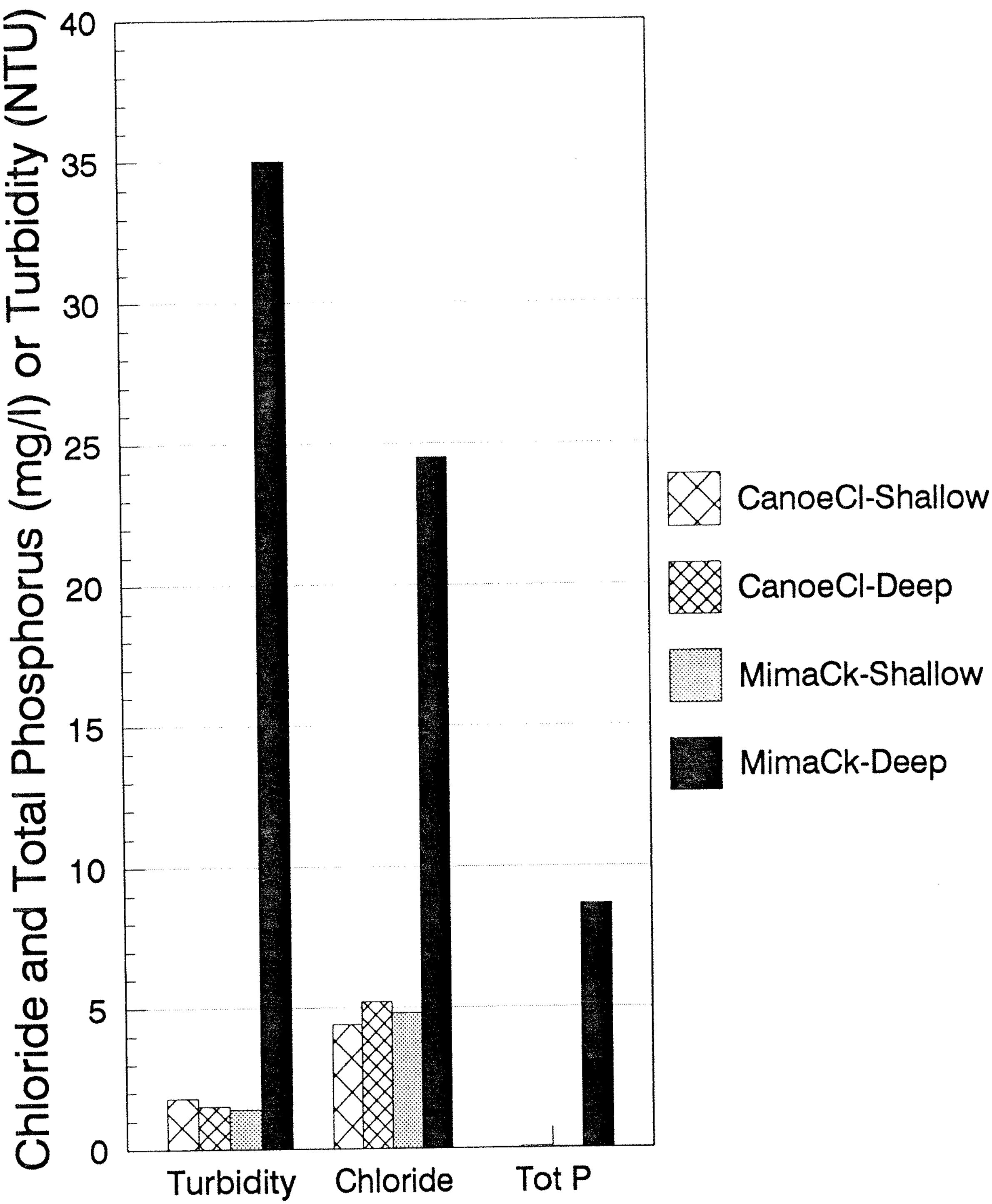


Figure 8. Black River Water Quality
Canoe Club and Mima Creek Pools
Sept 10-12, 1991: 3-day average

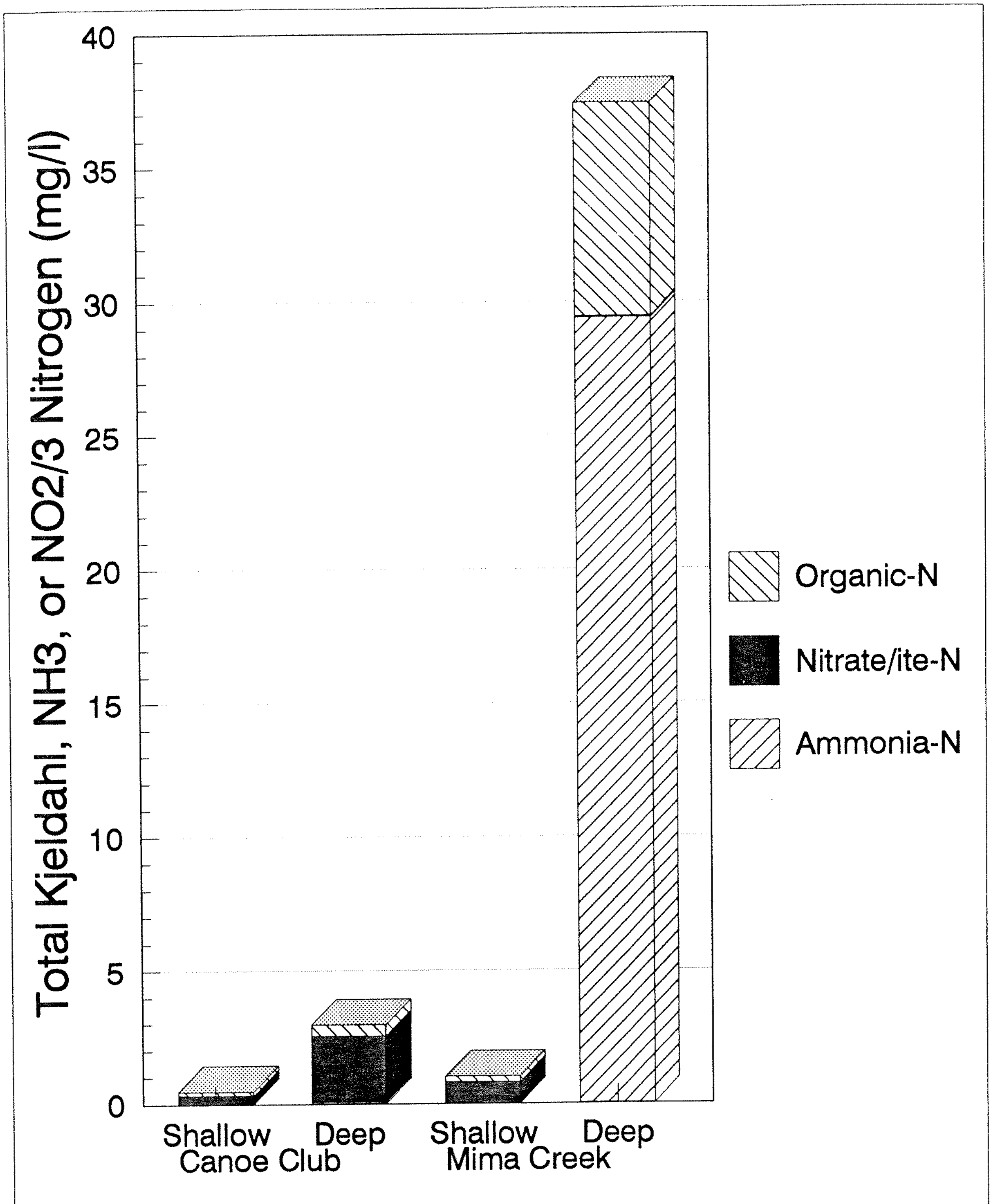
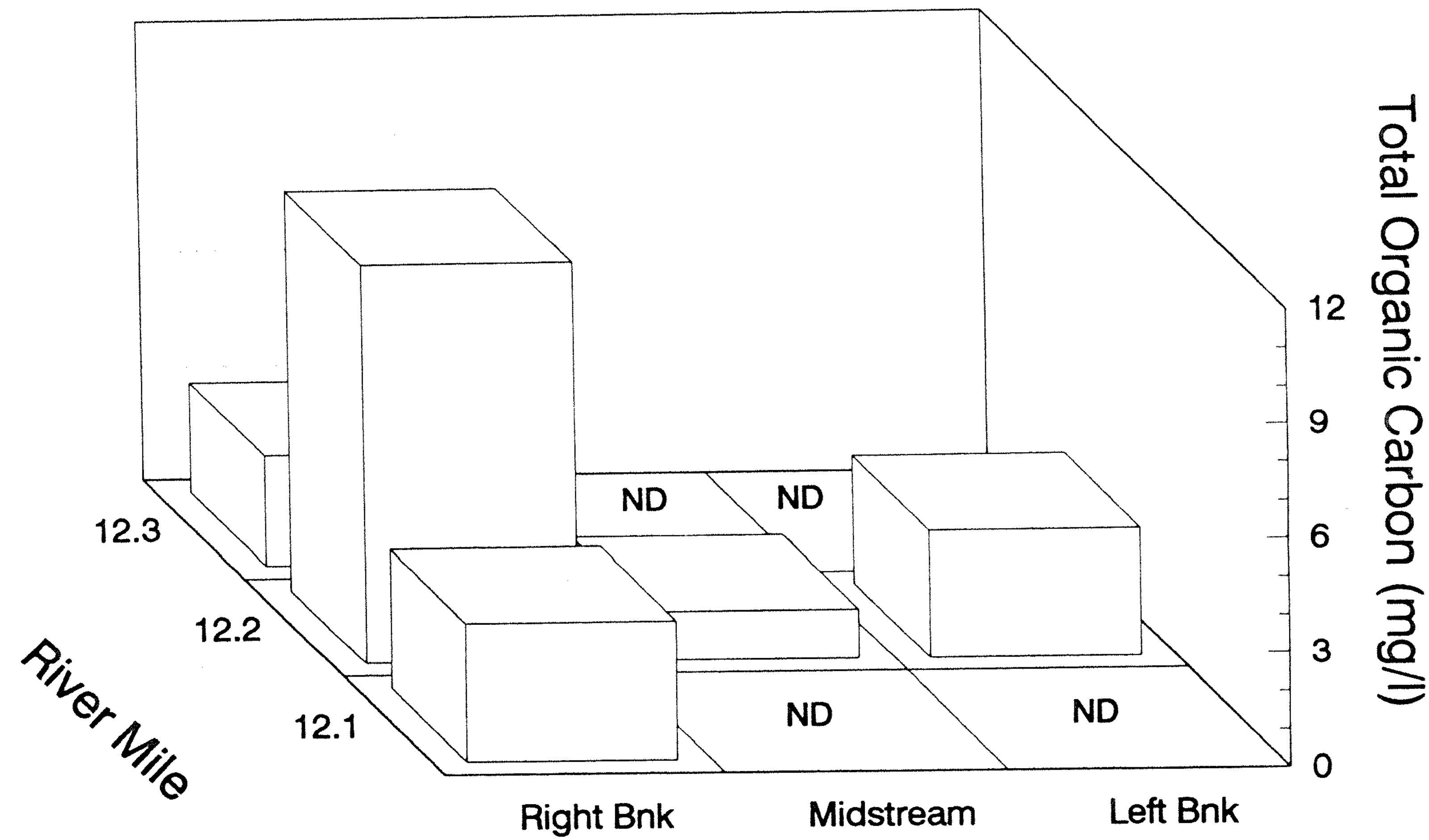


Figure 9. Black River Water Quality
Canoe Club and Mima Creek Pools
Sept 10-12, 1991: 3-day average



ND = No Data

Figure 10. Total Organic Carbon in Black River Near Drainage above Mima Creek October 9, 1991

APPENDICES

APPENDIX A

Black River above Mima Creek
Water Quality Analysis

F = Field Measurement
W = Winkler method DO titration
L = Laboratory Analysis

*** 7-22-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)
RM 14.1	F	0.0	18.5	7.7	82.2	88	6.5
	F	2.0	16.0	7.1	71.9	88	6.3
	F	4.0	11.7	6.7	61.7	140	6.1
RM 13.1	F	0.0	19.0	8.5	91.6	89	6.3
	F	2.0	17.7	8.2	86.1	91	6.3
	F	4.0	10.9	6.4	57.9	135	6.1
RM 11.9	F	0.0	19.6	9.3	101.5	89	6.5
	F	2.0	16.8	9.0	92.7	94	6.3
	F	4.0	14.6	2.8	27.5	110	6.1
	F	6.0	13.2	0.1	1.0	150	6.0

*** 8-15-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)
RM 14.1	F	0.0	18.50	8.03	85.7	89	7.11
	F	1.0	16.00	8.09	82.0	91	7.17
	F	2.0	15.23	8.01	79.8	90	7.17
	F	3.0	11.24	4.91	44.8	125	7.04
	F	4.0	11.00	4.65	42.2	125	6.98
RM 13.1	F	0.0	20.10	8.64	95.2	88	7.20
	F	1.0	17.93	9.03	95.2	89	7.22
	F	2.0	13.05	9.64	91.6	135	7.04
	F	3.0	11.08	6.26	56.9	141	6.98
	F	4.0	10.68	4.25	38.3	140	9.89
	F	5.0	10.41	4.28	38.3	152	6.84
	F	6.0		4.01			

APPENDIX A CONTINUED.

*** 8-15-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)
RM 12.2	F	RB	10.25	0.99	8.8	1600	7.62
RM 11.9	W	0.0	21.40	9.0	101.4		
	F	0.0	21.40	8.67	98.0	89	7.22
	F	1.0	18.21	8.89	94.3	94	7.17
	F	2.0	16.02	9.11	92.3	102	7.11
	F	3.0	15.59	0.28	2.8	184	7.03
	F	4.0	14.83	0.07	0.7	502	7.27
	F	5.0	14.34	0.03	0.3	607	7.33

*** 9-10-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)	FEC-COLI (#/100mL)	TOC (mg/l)	TURBTY (NTU)	CHLORIDE (mg/l)	Kjel-N (mg/l)	NH3-N (mg/l)	NO2/3-N (mg/l)	TotPhos (mg/l)
RM 14.1	L	0.0						22.0							
	F	0.0	15.66			94	6.77								
	L	0.9				97.1			4.62	1.8	4.5	0.474	0.019	0.329	0.025
	F	1.0	14.65			95	6.73								
	F	2.0	14.02			98	6.69								
	F	3.0	12.41			132	6.56								
	L	3.6				139.0				1.4	5.4	3.05	0.076	2.72	0.045
	F	4.0	11.29			139	6.53								
RM 11.9	F	0.0	17.96			95	6.94								
	F	1.0	16.95			96	6.85								
	L	1.1				101.0				1.4	4.7	0.658	<0.01	0.501	0.023
	F	2.0	15.61			111	6.70								
	F	3.0	14.88			122	6.59								
	F	4.0	14.60			243	6.60								
	L	4.4				627.0				35	23.8	36.1	28.3	0.079	8.430
	F	5.0	14.00			715	6.69								

APPENDIX A CONTINUED.

*** 9-11-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)	FEC-COLI (#/100mL)	TOC (mg/l)	TURBTY (NTU)	CHLORIDE (mg/l)	Kjel-N (mg/l)	NH3-N (mg/l)	NO2/3-N (mg/l)	TotPhos (mg/l)
RM 14.1	L	0.0						16.0							
	F	0.0	15.36	8.21	82.1	88	7.28								
	L	0.9				95.4			3.30	1.7	4.4	0.469	0.011	0.304	0.024
	F	1.0	14.36	7.18	70.2	90	7.11								
	F	2.0	13.97	7.13	69.1	91	7.04								
	F	3.0	11.64	4.80	44.2	96	6.86								
	L	3.7				136.0				1.6	5.3	2.90	0.062	2.64	0.088
	F	4.0	11.25	4.90	44.7	126	6.82								
RM 11.9	F	0.0	15.84	7.64	77.1	98	7.08								
	F	1.0	15.18	7.17	71.4	104	6.95								
	L	1.1				113.0				1.3	5.0	1.37	<0.01	1.05	0.031
	F	2.0	14.66	6.56	64.6	104	6.92								
	F	3.0	14.43	3.60	35.3	105	6.84								
	F	4.0	14.37	0.26	2.5	520	6.85								
	L	4.5				674.0				35	25.6	38.7	31.1	0.015	9.02
	F	5.0	13.74	0.19	1.8	796	6.83								

*** 9-12-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)	FEC-COLI (#/100mL)	TOC (mg/l)	TURBTY (NTU)	CHLORIDE (mg/l)	Kjel-N (mg/l)	NH3-N (mg/l)	NO2/3-N (mg/l)	TotPhos (mg/l)
RM 14.1	L	0.0						7.0							
	F	0.0	15.36	7.94	79.4	91	7.12								
	L	0.9				95.5			3.5	1.8	4.3		0.0	0.3	0.0
	F	1.0	14.53	7.58	74.4	91	6.98								
	F	2.0	13.82	7.44	71.9	91	6.91								
	L	2.6				105.0				1.5	4.9		0.047	2.1	0.0
	F	3.0	11.24	5.52	50.3	125	6.73								
	F	4.0	10.98	5.49	49.8	128	6.69								
RM 12.8	L	0.0						5.0							
	F	0.0	15.31	8.30	82.9	91	7.14								
	F	1.0	14.10	7.42	72.2	95	6.98								
	L	1.4				105.0				1.8	4.5		0.0	0.8	0.0
	F	2.0	12.30	6.98	65.2	126	6.84								

APPENDIX A CONTINUED.

*** 9-12-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)	FEC-COLI (#/100mL)	TOC (mg/l)	TURBTY (NTU)	CHLORIDE (mg/l)	Kjel-N (mg/l)	NH3-N (mg/l)	NO2/3-N (mg/l)	TotPhos (mg/l)
RM 11.9	L	0.0						8.0							
	F	0.0	15.55	8.17	82.0	98	7.26								
	F	1.0	14.69	7.51	74.0	101	6.99								
	L	1.1				105.0				1.6	4.6		0.0	0.8	0.0
	F	2.0	14.31	6.50	63.5	106	6.84								
	F	3.0	13.97	6.48	62.8	107	6.82								
	F	4.0	14.15	0.15	1.5	585	6.82								
	L	4.6				642.0				36.0	24.1		28.7	0.0	8.5
	F	5.0	13.58	0.12	1.2	822	6.81								

*** 9-25-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)	FEC-COLI (#/100mL)	TOC (mg/l)
RM 14.1	F	0.0	13.78	8.75	84.5	85	6.60		
	F	1.0	13.72	8.70	83.9	85	6.56		
	F	2.0	13.63	8.66	83.3	85	6.54		
	F	3.0	11.67	9.82	90.4	115	6.49		
	F	4.0	11.19	8.52	77.6	123	6.42		
RM 13.6	L	0.0						4	
	F	0.0	14.17	9.74	94.9	87	6.59		
	F	1.0	13.87	9.75	94.3	87	6.63		
	F	2.0	13.75	9.79	94.5	87	6.60		
	F	3.0	11.30	9.89	90.3	128	6.48		
RM 13.1	F	0.0	14.39	9.82	96.1	90	6.60		
	F	1.0	14.03	9.82	95.3	90	6.61		
	F	2.0	13.02	10.87	103.2	117	6.51		
	F	3.0	10.89	7.43	67.2	139.0	6.35		
	F	4.0	10.66	6.07	54.6	141	6.28		
	F	5.0	10.40	5.10	45.6	148	6.24		

APPENDIX A CONTINUED.

*** 9-25-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)	FEC-COLI (#/100mL)	TOC (mg/l)
RM 12.8	L	0.0						4	
	F	0.0	14.47	9.97	97.7	91	6.62		
	F	1.0	13.85	10.02	96.9	93	6.64		
	F	2.0	11.93	10.02	92.8	118	6.48		
RM 12.3	F	LB	15.38	10.14	101.4	95	6.75		
	F	0.0	15.13	9.77	97.2	94	6.69		
	F	1.0	14.51	9.81	96.3	93	6.65		
	F	2.0	14.25	9.33	91.0	100	6.60		
	F	3.8	13.68	9.26	89.2	101	6.56		
	F	RB	17.20	9.67	100.5	92	6.78		
RM 12.2	F	LB	15.62	10.53	105.8	93	6.82		
	L	0.0						4.0	
	F	0.0	15.34	9.89	98.8	93	6.69		
	F	1.0	14.65	9.90	97.4	93	6.70		
	F	2.0	14.03	9.37	91.0	107	6.56		
	F	3.0	13.63	9.49	91.3	103	6.53		
	F	4.0	13.53	0.20	1.9	146	6.54		
	F	RB	17.24	9.87	102.6	158	6.88		
	L	Ditch						160.0	
RM 12.1	F	LB	15.63	9.98	100.3	93	6.84		
	F	0.0	16.00	9.81	99.4	96	6.76		
	F	1.0	14.79	9.90	97.7	93	6.71		
	F	2.0	14.32	9.67	94.5	98	6.65		
	F	3.0	13.83	9.62	93.0	102	6.57		
	F	4.0	13.63	0.67	6.4	135	6.47		
	F	RB	17.71	9.43	99.0	94	6.87		

APPENDIX A CONTINUED.

*** 9-25-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)	FEC-COLI (#/100mL)	TOC (mg/l)
RM 11.9	F	0.0	15.87	9.85	99.5	94	6.68		
	F	1.0	15.27	9.89	98.6	93	6.67		
	F	2.0	14.36	10.07	98.5	93	6.68		
	F	3.0	13.75	9.87	95.2	100	6.59		
	F	4.0	13.53	1.52	14.6	116	6.49		
	F	5.0	13.61	0.19	1.8	691	6.62		
RM 11.8	L	Mima Ck						1100.0	
RM 11.7	L	0.0						16.0	

*** 10-9-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)	FEC-COLI (#/100mL)	TOC (mg/l)
RM 14.1	F	0.0	11.88	8.35	77.3	88	6.53		
	F	1.0	11.49	8.26	75.8	88	6.46		
	F	2.0	11.35	8.33	76.2	88	6.41		
	F	3.0	11.08	8.02	72.9	92	6.32		
	F	4.0	10.83	7.03	63.5	107	6.28		
RM 13.6	F	0.0	11.90	8.83	81.7	87	6.67		
	F	1.0	11.55	8.79	80.7	87	6.55		
	F	2.0	11.45	8.87	81.3	88	6.45		
	F	3.0	10.57	8.53	76.6	133	6.30		
	F	4.0	9.85	7.39	65.2	124	6.24		
RM 13.1	F	0.0	12.01	9.17	85.1	88	6.64		
	F	1.0	11.91	9.10	84.3	87	6.52		
	F	2.0	11.35	9.92	90.7	106	6.40		
	F	3.0	10.34	6.12	54.7	137	6.21		
	F	4.0	10.15	4.88	43.4	138	6.13		
RM 12.8	F	0.0	12.27	9.22	86.1	88	6.73		
	F	1.0	11.71	9.16	84.4	89	6.53		
	F	2.0	10.40	8.40	75.1	131	6.24		

APPENDIX A CONTINUED.

*** 10-9-91 ***

STATION		LOC (m)	TEMP (oC)	DO (mg/l)	DO (% Sat)	CCOND (umho/cm)	pH (s.u.)	FEC-COLI (#/100mL)	TOC (mg/l)
RM 12.3	F	LB	12.77	10.58	99.9	95	6.76		
	F	0.0	12.65	9.89	93.1	93	6.61		
	F	1.0	12.30	9.87	92.2	93	6.58		
	F	2.0	11.86	1.10	10.2	94	6.49		
	F	3.0	11.76	8.26	76.2	96	6.4		
	F	3.8	11.74	4.80	44.3	122	6.25		
	F	RB	14.32	9.98	97.5	95	6.33		2.90
RM 12.2	F	LB	12.55	10.81	101.6	97	6.75		3.34
	F	0.0	12.81	9.83	92.9	94	6.61		1.31
	F	1.0	12.46	9.88	92.6	94	6.53		
	F	2.0	11.90	11.28	104.4	97	6.51		
	F	3.0	11.87	8.52	78.8	101	6.35		
	F	4.0	11.64	5.31	48.9	144	6.31		
	F	RB	15.05	9.88	98.1	297	6.88		10.5
RM 12.1	F	LB	12.64	10.45	98.4	95	6.72		
	F	0.0	12.65	9.91	93.3	94	6.68		
	F	1.0	12.55	9.88	92.8	94	6.59		
	F	2.0	11.91	10.31	95.5	95	6.55		
	F	3.0	11.80	9.38	86.6	99	6.45		
	F	4.0	11.60	6.91	63.5	116	6.37		
	F	RB	16.44	9.93	101.5	93	6.66		3.69
RM 11.9	W	0.0	12.80	9.7	91.4				
	W	0.0	12.80	9.6	90.4				
	F	0.0	12.80	10.02	94.7	94	6.70		
	F	1.0	12.62	9.96	93.7	94	6.58		
	F	2.0	12.21	10.51	98.0	94	6.51		
	F	3.0	11.84	10.03	92.7	97	6.45		
	F	4.0	11.71	9.39	86.6	100	6.43		
	F	5.0	11.64	5.04	46.4	203	6.35		
	F	5.2	12.24	0.34	3.2	693	6.49		

APPENDIX B

Calculation Of Un-ionized Ammonia Concentration and Criteria.
Based on EPA Gold Book (EPA 400/5-86-001). Lotus File AMMONIA.WK1

INPUT

1. Sample Ambient Temperature (deg C; 0<T<30)	14
2. Sample Ambient pH (6.5<pH<9.0)	6.75
3. Sample Total Ammonia (ug N/L)	30000
4. Acute TCAP (Salmo	20
5. Chronic TCAP (Salmonids present- 15; absent- 20)	15

OUTPUT

1. Intermediate Calculations:

Acute FT	1.51
Chronic FT	1.51
FPH	4.37
RATIO	39
pKa	9.6
Fraction Of Total Ammonia Present As Un-ionized	0.1425%

2. Sample Un-ionized Ammonia Concentration (ug N/L)	42.8

3. Un-ionized Ammonia Criteria:

Acute (1-hour) Un-ionized Ammonia Criterion (ug N/L)	32.3
Chronic (4-day) Un-ionized Ammonia Criterion (ug N/L)	2.5

4. Total Ammonia Criteria:

Acute Total Ammonia Criterion (ug N/L)	22,652
Chronic Total Ammonia Criterion (ug N/L)	1,781